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Location Information Verification cum Security using TBM in Geocast Routing

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Abstract

Location information security in geocast routing in VAVETs has not been explored accountably. Some routes have been tried to explore in this direction using traditional authentication and key management technique which increases protocol complexity and computational overhead. To address the issues of traditional security techniques, this paper proposes, Location Information Verification cum Security (LIVES) based on Transferable Belief Model (TBM). In LIVES, two level location information verification is carried out. In level-1 tiles based verification technique is used to verify the correctness of location information. In level-2, collective belief about the announced position information of each vehicle is calculated using TBM with the help of neighbor list information from all neighboring vehicles. A secured geocast routing (SGR) protocol is developed using the two level location verification technique. Simulations are carried out using ns-2 and results have been analyzed in terms of location error probability. The comparative analysis of simulation results confirm the better suitability of LIVES ascompared to the state-of-the-art technique: A-VIP in high dynamic vehicular adhoc network environment.

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Keywords: Location information; Security; Verification; Geocast routing; Transferable belief model; Vehicular adhoc networks

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1. Introduction

Recently, number of projects in European Commission [1] confirms that VANETs has gained remarkable research.Liang et al. [2] describes that Intelligent Transportation System (ITS) applications are based on the framework of VANETs[2]. ITS constitute on various applications such as co-operative traffic monitoring, blind crossing, prevention of collisions, control of traffic flows nearby information services as discussed by Li et al. [3].

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However, another important application of VANETs is supply of internet access to vehicular nodes during their movement. As this Internet connectivity access provides the users an opportunity of browsing and gaming as suggested by Benslimane et al. [4], and Tonguz and Boban [5].To realize these applications, information dissemination in vehicular traffic environment with reliability and efficiency has become one of the fundamental research issues as investigated by Gerla et al. [6]. Various techniques have been suggested in literature as reviewed by Suthaputchakun et al. [7]. One of the most preferred information dissemination technique in VANETs is geocast routing as investigated by Kaiwartya and Sushil [8, 9]. Geographic location discovery of vehicles is one of the important functional modules of geocast routing in vehicular traffic environment as explored by Fiore et al. [10]. During geocasting, geographic location of next hop vehicle is obtained by broadcasting location query control packets in the neighborhood which is continuously re-broadcastedas used by Kaiwartya et al. [11]. Location discovery process creates a security hole for malicious location attacker vehicle which tries to disrupt the functionality of geocast routing by introducing either false location claim or modified the other vehicles location claim. Various security enable techniques as reviewed by Mejri et al. [12] have been used in geocast routing to address the security concern but most of the techniques are based on cryptography which is inappropriate for highly dynamic vehicular traffic environment.

To address the aforementioned concern, this paper proposes Location Information Verification cum Security (LIVES) based on Transferable Belief Model (TBM) in geocast routing. In LIVES, two level location information verification is carried out. In level-1,computation of Tiles based Verification (TV) probability for the location information announced by each neighboring vehicles is mathematically derived. In level-2, Collective belief computation is mathematically derived explaining the major components of TBM in the context of location information problem. A secured geocast routing (SGR) protocol is developed using the two level location verification technique. Simulations are carried out using ns-2 and results have been analyzed in terms of location error probability. Results of LIVES are compared with that of Verification and Inference of Position using Anonymous beaconing (A-VIP) suggested by Malandrino et al. [13] and Without considering LIVES (W-LIVES) approach. The rest of the paper is organized into following sections. In section 2, related literatures are critically reviewed considering the main security module limitation, strength and limitations. In section 3, complete formation of LIVES along with SGR is presented. In section 4, simulation and analysis of results are discussed. Section 5 concludes the work presented in this research article.

2. Related Work

In geocast routing, Location discovery process creates a security hole for malicious location attacker vehicle which tries to disrupt the functionality of geocast routing by introducing either false or modified location claim. Although, the issues has not been explored accountably, yet few research works have explored location verification in vehicular communication. Verification and Inference of Position using Anonymous beaconing (A-VIP) has been suggested by Malandrino et al. [13]. It is a server based approach for location verification. The verification technique also infers the correct location of position faking vehicles and thus secures location information in vehicular communication. Although, the technique is claimed to be promising but the requirement of server for verification and inference is reducing the importance of the technique due to the growing importance of distributed approached in highly dynamic vehicular environment.

A location verification technique has been suggested by Zhang et al. [14] using cooperative neighbor vehicle. The technique uses Radio Frequency (RF) based location verification approach in which two vehicles, namely a verifier and a cooperator verify claimed location of a vehicle. Verifier and cooperator vehicles send a challenge message to the vehicle which is claiming a location in the network. The vehicle claiming a location replies the challenge messages sent by verifier and cooperator. The two replies of the challenge are used to verify the claiming location of the vehicle based on Time-of-Flight (ToF) on these two replies. Although, the accuracy of ToF based location verification is good for static network but in highly dynamic vehicular traffic environment, the accuracy is not reliable. The impact of vehicle speed on the ToF based distance calculation has not been considered in the above approach.

An approach to overcome non-line of sight (NLOS) situation in location verification has been suggested by Abumansoor and Boukerche [15] using cooperative neighbor vehicles. Due to NLOS condition, when a vehicle (verifier) is not able to verify the Location claim of another neighboring vehicle then the verifier vehicle uses other neighboring vehicles with no NLOS problem. In this verification approach, triangle based distance calculation is used with simple control packet communication. Although, angle based distance calculation is quite successful in static network, but in highly dynamic vehicular adhoc networks, its performance could not be guaranteed in terms of accuracy. Various position verification techniques that could be used in vehicular traffic environment have been investigated by Leinmuller et al. [16] . Authors claimed that the suggested verification and inference techniques did not require special hardware or infrastructure support. Verification is mainly based on autonomous sensors, cooperative sensors and digital street map.

3. LIVES

In this section, two levels location verification technique is presented.

3.1 Level-1: Tiles based Verification

Let T is the set of tiles and V is the set of neighboring vehicles of current forwarding vehicle (cf. Figure 1). The position information of each tile in terms of latitude and longitude $t_{la,lo}$ are calculated dynamically by current forwarding vehicle and stored in a setP^t. The position information of each border area tiles have been approximated using a specific error balancing constante_b^t. Let the current forwarding vehicle is on tile$a$. For each pair of tiles $(a, b) \in T$ the quality of received signal strengthq_b^t has been calculated using shadowing propagation model and stored in a set Q^t. The announced position information $v_{la,lo}$of each neighboring vehicle of current forwarding vehicle is stored in a setP^v. The received signal strength of each announced position information q_i^v for v_i has also been recorded and stored in a set Q^v .

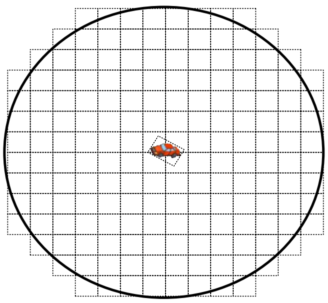

Figure 1. Transmission range of a vehicle as a set of tiles

Algorithm 1:Tiles based Verification (TV)

```
Input : δ
V¹ = ∅
for(∀ v_i ∈ V)
    if (v_i ∈ v_j's neighbor list)
        determine T_{v_i} using shadowing propagation model
        calculate p_{v_i}^{TV} using equation (1)
        if (p_{v_i}^{TV} > δ)
            V¹ = {V¹ ∪ v_i}
        endif
    endif
endfor
Output V¹
```

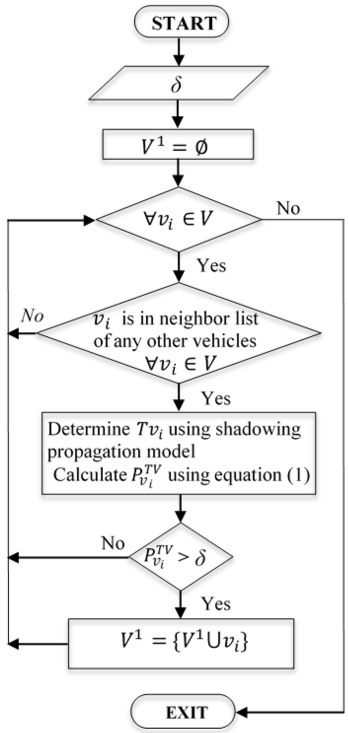

Figure 2. Flowchart of tiles based verification algorithm

The level-1 verification is executed for each $v_i \in V$ that has announced its position information and at least one other neighboring vehicle $v_j \in V$ of current forwarder has reported the presence of v_i in its neighbor list. The probability of tiles based verification $p_{v_i}^{TV}$ of a vehicle v_i can be calculated as expressed in Equation (1).

$$p_{v_i}^{TV} = \frac{1}{|T_{v_i}|}, v_i \in V \tag{1}$$

where T_{v_i} is the set of all tiles where vehicle v_i can be approximated based on received signal strength. If the probability $p_{v_i}^{TV}$ is greater than a threshold value δ, v_i is considered to pass the tiles based verification test. Set of steps of Tiles-based Verification (TV) is provided in algorithm-1. A flowchart is also give in Figure 2.

3.2 Level-2: Verification using TBM

In level-2, collective belief b_j^c is computed for each vehicle $v_j \in V$ using Transferable Belief Model (TBM) discovered by Smets and Kennes [17]. The individual belief $b_{v_k,j}^i$ of vehicle $v_k \in V - \{v_k\}$ about a vehicle v_j and the individual belief $b_{t_k,j}^i$ of a tile $t_k \in T$ are combined to calculate b_j^c. The calculation of individual belief and use of TBM theory is described below.

- Frame of Discernment

A set Ω containing each possible states of a system is called Frame of Discernment in TBM theory. In the position verification systems the set of position of tiles P^t is frame of discernment and can be represented as given by Equation (2).

$$\Omega = P^t = \{P_{la,lo}^t(t_i), \forall\, t_i \in T\} \tag{2}$$

- Individual Belief calculation

The individual belief of each tile $b_{t_b,j}^i$ is calculated as expressed by Equation (3).

$$b_{t_b,j}^i = \frac{q_b^t - q_j^v}{q_b^t}, 0 \le b_{t_b,j}^i \le 1 \tag{3}$$

Where, q_b^t represents quality of received signal of tile t_b and q_j^v represents quality of received signal of vehicle v_j. The individual belief $b_{v_k,j}^i$ of each vehicle $v_k \in V$ is calculated by using various matrices such as number of outgoing packets routed though n_{out}, number of other neighboring vehicles n_n having entry of v_i as neighbor, difference of speed s_d, number of incoming packets though n_{in}, percentage quality q_p of received signal strength as compared to ideal received signal. The $b_{v_k,j}^i$ can be calculated expressed by Equation (4).

$$b_{v_k,j}^i = w_{out}\left(\frac{n_{out}^{th} - n_{out}}{n_{out}^{th}}\right).w_n\left(\frac{n_n^{th} - n_n}{n_n^{th}}\right).w_d\left(\frac{s_d^{th} - s_d}{s_d^{th}}\right).w_{in}\left(\frac{n_{in}^{th} - n_{in}}{n_{in}^{th}}\right).w_p\left(\frac{q_p^{th} - q_p}{q_p^{th}}\right) \tag{4}$$

Where, w_{out}, w_n, w_d, w_{in}, w_p are weights of corresponding parameters and used to adjust the impact of parameters.

- Transformation of Individual Beliefs into Collective Belief

The current forwarding vehicle collects all the individual beliefs of tiles as well as neighboring vehicles and performs pignistic transformation. The collective belief of a vehicle $v_j \in V$ can be calculated as given by Equation (5).

$$b_j^c = \prod_{b=1}^{|T|} b_{t_b,j}^i + b_{v_j,\ CF}^i + \sum_{b=1}^{|T|}\left(1 - b_{t_b,j}^i\right) \prod_{\substack{x,y,z,..l=1 \\ x\neq y\neq\ldots\neq z\neq i}}^{|T|} \underbrace{\left(b_{t_b,j}^i\right)_x \left(b_{t_b,j}^i\right)_y \ldots \left(b_{t_b,j}^i\right)_z}_{1:|T|-1\ terms} \tag{5}$$

The collective belief b_j^c is used to evaluate a neighboring vehicle during geocasting of packets. The complete geocasting algorithm by using two-level verification has been provided in the next section.

- Secure Geocast Routing (SGR) Algorithm

The above two level location verification technique has been utilized to realize secure geocast routing in algorithm 2. A flowchart of SGR algorithm is also provided in Figure 3.

Algorithm 2: SGR
Notations
CFV: Current Forwarding Vehicle; SV: Source Vehicle
SSV^{TV}: Set of Secure Vehicles by TV; T: Set of tiles for CFV
DV: Destination Vehicle; NHV: Next Hop Vehicle
SOV^{TBM}: Set of One hop Neighbour Vehicles;
Input
Process
1.initialization
$SSV^{\text{TV}} = NHV = SONV = \phi$
2.for each ($t_b \in$ T)
calculate $b_{t_b,j}^i$ using equation (3)
endfor
3. find SSV^{TV} by executing TV algorithm
4. for each ($v_k \in SSV^{\text{TV}}$)
calculate $b_{v_k,j}^i$ using equation (4)
endfor
5. for each ($v_j \in SSV^{\text{TV}}$)
calculate b_j^cusing equation (5)
endfor
6. select the vehicle having maximum collective belief b^c, let v_j
7.$NHV = v_j$
8. transmit the packet to NHV and $NHV = CFV$
9. exit
Output:NHV (v_j)

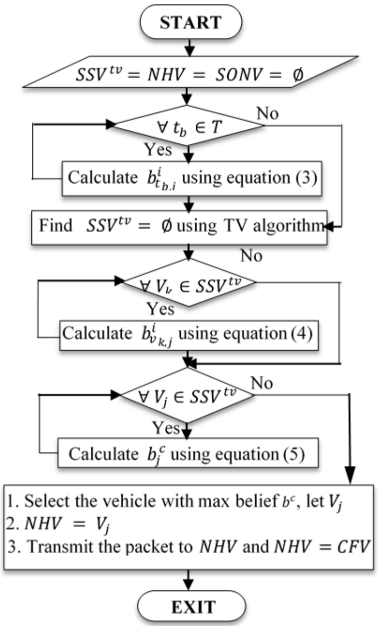

Figure 3: Flowchart of secure geo cast routing algorithm

4. Simulation and Analysis of Results

In this section, simulation process and analysis of results are described.

4.1 Simulation Environment

The simulations are carried out in network simulator ns-2.34. To generate realistic vehicular network environment such as roads, junctions, traffic lights, etc., Mobility model generator for Vehicular networks (MOVE) is used. The essential scenario of vehicular traffic environment has been setup and implemented using the two main modules of MOVE; namely, road map editor and vehicle movement editor. A road network of four junction points with two lanes in each road is used. The distance between junctions is considered $1000\, m$ in simulation area. Malicious vehicles are considered for generating false location information during geo-location discovery. The width of the considered lane on roads is $5\, m$. The number of normal vehicles used is in the simulation is in the range 100-500 in all the lanes. The number of malicious vehicles is in the range 10-50 in all the lanes. Different vehicle speeds is considered for different vehicles during simulation. The speed of vehicles is in the range 5-60 Km/h for each simulation. Packet size of 512 bytes, transmission range of $250\, m$, wireless channel type, shadowing propagation model, traffic type as CBR, Omni directional antenna model, 802.11p MAC protocol and 600 s total simulation time are other basic parameters setup used in the simulation of LIVES. Different source vehicle and geocast region is randomly selected from two pre-determined junctions which is kept same for all the ten simulation runs for a recoding simulation points used in results.

4.2 Analysis of Simulation Results

In this section results obtained for LIVES are analyzed.

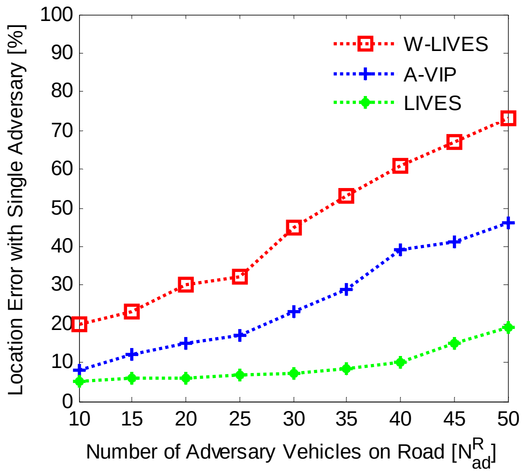

Figure 4. Location error percentage versus number of adversary vehicles for single adversary vehicle in each vehicle's transmission range

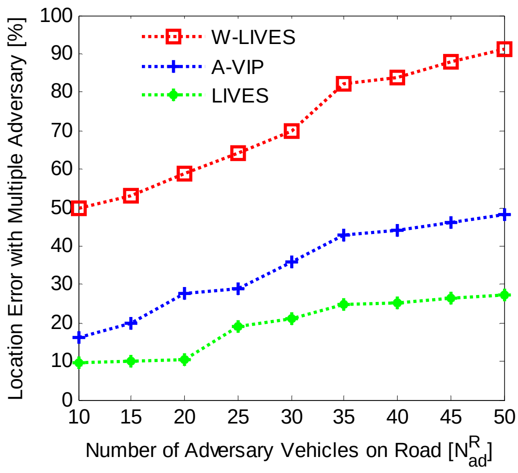

Figure 5. Location error percentage versus number of adversary vehicles for multiple adversary vehicle in each vehicle's transmission range

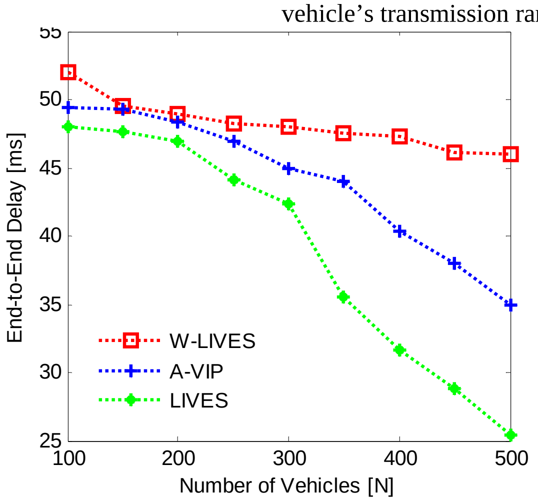

Figure 6. Comparison of end-to-end delay with mixed adversary vehicles (ten) in transmission range of vehicles

Results obtained through the simulations carried out considering single adversary vehicle in each vehicle's transmission range are depicted in Fig. 4.It can be clearly observed that location error probability of all the considered techniques increases with the increase in total number of adversary vehicles. With 50 total number of adversary vehicles, location error probabilities are approximately 20%, 35% and 75% for LIVES, A-VIP and W-LIVES respectively. The increment in location error probability is lower in case of LIVES as compared to A-VIP and W-LIVES. This is due to the fact that LIVES use distributed tiles based location verification effectively identifies false location announcement by single adversary vehicle in transmission range. Results obtained through the simulations carried out consideringmultiple adversary vehicles in each vehicle's transmission range are depicted in Fig. 5. It clearly reveal that location error probabilityof all the considered techniques increases with the increase in total number of adversary vehicles. With 50 total number of adversary vehicles, location error probabilities are approximately 25%, 40% and 95% for LIVES, A-VIP and W-LIVES respectively.The increment in location error probability is lower in case of LIVES as compared to A-VIP and W-LIVES. This can be attributed to the fact that LIVES uses level 2 collective belief based adversary identification which efficiently find out group of adversaries in transmission range. Results obtained through the simulations carried out consideringmixed adversary vehicles in the transmission range of differentvehicles are depicted in Fig. 6. In some transmission range single adversary is considered and in some transmission range multiple adversaries are considered. It can be clearly observed that end-to-end delay decreases faster in case of LIVES as compared to that of A-VIP and W-LIVES with the increase in total number of normal vehicles in the network area. The end-to-end delay decreases from 47 to 25in case of LIVES whereas it decreases from 49 to 35in case of A-VIP.

5. Conclusion and Future Work

In this dissertation, a two level location verification technique named as LIVES has been proposed. The first level location verification is based on concept of tiles. The second level location verification is based on collective belief that is calculated using TBM theory. Tiles based verification has been proved single adversary vehicle detector in transmission range through simulation results. TBM based verification effectively identifies multiple adversary vehicles in transmission range. As soon as the adversary vehicles are identified end-to-end delay in geocasting reduces quickly. In future research, we will investigate effective optimization technique to select best possible next hop vehicle from all the non-adversary vehicles.

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